METHOD AND APPARATUS FOR DOWNHOLE PIPE OR CASING REPAIR

BACKGROUND OF THE INVENTION

The subject matter of the present invention relates to a method and apparatus for downhole pipe or casing repair including a corrosion monitoring tool for evaluating the extent of corrosion on an internal surface of a pipe, a surface treatment apparatus, such as a sand blaster, for cleaning the internal surface of the pipe and removing the corrosion, and a plating apparatus for plating a new metallic layer on the internal surface of the pipe.

Corrosion in an oil or gas well is a problem. Tubing disposed downhole in a wellbore can become corroded with rust and, as a result, it is often necessary to determine the extent of that corrosion on an internal surface of the tubing disposed downhole. Corrosion monitoring tools can determine the extent of that corrosion, however, when the corrosion monitoring tool is disposed downhole, there exists no additional apparatus disposed downhole with the corrosion monitoring tool for concurrently repairing the internal surface of the corroded tubing. Therefore, although it would be desirable to determine the extent of the corrosion on the internal surface of the pipe, there exists no additional apparatus for concurrently repairing the corroded pipe downhole without pulling the pipe out of the wellbore, replacing the pipe, and increasing the rig-time and the resultant costs to a customer.

Therefore, a need exists to provide a downhole pipe or casing repair apparatus adapted to be disposed in a wellbore which would include a surface treatment apparatus and a plating apparatus in addition to the corrosion monitoring tool, the downhole pipe or casing repair apparatus using the corrosion monitoring tool to monitor the extent of the corrosion on an internal surface of a pipe disposed downhole and, when the corrosion is

detected, repairing the internal surface of the pipe by using the surface treatment apparatus to remove the corrosion from the internal surface of the pipe and using the plating apparatus to plate a new metallic layer on the internal surface of the pipe disposed downhole.

SUMMARY OF THE INVENTION

Accordingly, one aspect of the present invention includes a downhole pipe repair apparatus, comprising: a surface treatment apparatus adapted for cleaning an interior surface of the pipe; and a plating apparatus adapted for plating a new surface on the interior surface of the pipe after the surface treatment apparatus cleans the interior surface of the pipe.

Another aspect of the present invention includes a downhole pipe repair apparatus, comprising: a surface treatment apparatus adapted for cleaning an interior surface of the pipe; a plating apparatus adapted for plating a new surface on the interior surface of the pipe after the surface treatment apparatus cleans the interior surface of the pipe; and a corrosion monitoring tool adapted for examining the interior surface of the pipe after the plating apparatus plates the new surface on the interior surface of the pipe.

Another aspect of the present invention includes a method for downhole pipe repair, the method comprising: cleaning an interior of the pipe, and plating a new surface on the interior of the pipe after the cleaning step.

Another aspect of the present invention includes a method for downhole pipe repair, the method comprising: examining the interior of the pipe, cleaning the interior of the pipe after the examining step, and plating a new surface on the interior of the pipe after the cleaning step.

Another aspect of the present invention includes a method for downhole pipe repair, the method comprising: examining the interior of the pipe, cleaning the interior of the pipe after the examining step, plating a new surface on the interior of the pipe after the cleaning step, and re-examining the interior of the pipe after the plating step.

Further scope of applicability of the present invention will become apparent from the detailed description presented hereinafter. It should be understood, however, that the detailed description and the specific examples, while representing a preferred embodiment of the present invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become obvious to one skilled in the art from a reading of the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

A full understanding of the present invention will be obtained from the detailed description of the preferred embodiment presented hereinbelow, and the accompanying drawings, which are given by way of illustration only and are not intended to be limitative of the present invention, and wherein:

figure 1 illustrates a preferred embodiment of the downhole pipe or casing repair apparatus of the present invention;

figure 2 illustrates a more detailed construction of the downhole pipe or casing repair apparatus of figure 1 of the present invention;

figure 3 illustrates a detailed construction of the surface treatment apparatus portion of the downhole pipe or casing repair apparatus of figure 2,

figure 4 illustrates an alternate embodiment of the corrosion monitoring tool of figure 1, figure 2 illustrating one embodiment of the corrosion monitoring tool of figure 1, and figure 4 illustrating another embodiment of the corrosion monitoring tool of figure 1, and

figures 5A and 5B illustrate the principle behind the operation of the alternate embodiment of the corrosion monitoring tool of figure 4.

DESCRIPTION OF THE INVENTION

Referring to figure 1, a downhole pipe or casing repair apparatus 10, adapted to be disposed inside a tubing or pipe or casing 16 in a wellbore 12, is illustrated. In figure 1, the downhole pipe or casing repair apparatus 10 includes a corrosion monitoring tool 14 adapted for examining the internal wall of the tubing 16 to determine the extent of any corrosion or rust which may exist on the inside of the tubing 16, a surface treatment apparatus 18 adapted for cleaning the inside of the tubing 16 when corrosion or rust is determined to exist on the inside of the tubing 16, a plating apparatus 20 adapted for plating a new metallic layer on the inside of the tubing 16 when the surface treatment apparatus 18 cleans the inside of the tubing 16, a packer sealing apparatus 22 adapted for sealing off the surface treatment apparatus 18 from the corrosion monitoring tool 14 when the surface treatment apparatus 18 is cleaning the inside of the tubing 16, and a packer sealing apparatus 23 adapted for sealing off the plating apparatus 20 from the surface treatment apparatus 18 when the plating apparatus 20 is plating the new metallic layer on the inside of the tubing 16.

Referring to figure 2, a detailed construction of the downhole pipe or casing repair apparatus 10 of figure 1 is illustrated. In figure 2, the downhole pipe or casing repair apparatus 10 includes the corrosion monitoring tool 14 which is owned and operated by Schlumberger Technology Corporation of Houston, Texas. Examples of such corrosion monitoring tools 14, which are owned and operated by Schlumberger Technology Corporation, include the CPET tool, the METT tool, and the CET tool. The corrosion

monitoring tool 14 includes a plurality of fingers 14a extending from a central conductor 14b, the fingers 14a being adapted for contacting the inside 16a of the tubing 16 and flexing when the corrosion monitoring tool 14 is pushed downwardly or pulled upwardly inside the tubing 16. During the flexing of the fingers 14a, an electrical signal is generated in each finger 14a which is proportional to and representative of the extent of the corrosion which exists on the inside 16a of the pipe or tubing or casing 16. The electrical signal from each finger 14a propagates uphole and is recorded on a log which displays the extent of the corrosion existing on the inside 16a of the tubing 16. The downhole pipe or casing repair apparatus 10 further includes a surface treatment apparatus 18 which further includes a cleaning apparatus 18a adapted for cleaning the inside 16a of the pipe or tubing or casing 16 and a container 18b adapted for collecting any corrosive elements which are removed from the inside 16a of the pipe or tubing or casing 16 when the cleaning apparatus 18a cleans the inside 16a of the tubing or casing 16. A packer sealing apparatus 22 is disposed between the corrosion monitoring tool 14 and the surface treatment apparatus 18, the packer sealing apparatus 22 sealing off the surface treatment apparatus 18 from the corrosion monitoring tool 14 inside the pipe or tubing or casing 16 when the surface treatment apparatus 18 is cleaning the inside 16a of the pipe or tubing or casing 16. The downhole pipe or casing repair apparatus 10 further includes a plating apparatus 20, the plating apparatus 20 further including an anode 20a, a cathode 20b which is the pipe or tubing or casing 16, and an electrolyte 20c disposed between the anode 20a and the cathode 20b. Note the corroded areas 24 which exist on the inside 16a of the pipe or tubing or casing 16. A spacer/centralizer 20d will centralize the anode 20a inside the pipe or tubing or casing 16. The anode 20a is adapted for depositing a metallic layer on the cathode 20b via an electrolytic reaction when a voltage "V" is applied across the anode 20a and cathode 20b. Assume that the plus side of voltage V is applied to the anode 20a via a central conductor 21 and the negative side of the voltage V is applied to the tubing or casing 'cathode' 20b. The metallic layer can be either a Nickel (Ni), Chromium (Cr), Iron (Fe), or Copper (Cu) layer. A packer sealing apparatus 23 is disposed between the plating apparatus 20 and the surface treatment apparatus 18, the packer sealing apparatus 23 sealing off the plating apparatus 20 from

the surface treatment apparatus 18 inside the pipe or tubing or casing 16 when the plating apparatus 20 is plating a new metallic layer on the inside 16a of the pipe or tubing or casing 16.

Referring to figure 3, a detailed construction of the cleaning apparatus 18a of figure 2 is illustrated. In figure 3, although the cleaning apparatus 18a can be either a mechanical cleaning apparatus or an ultrasonic cleaning apparatus, the cleaning apparatus 18a of figure 3 includes a central bore 18a1 in which a fluid or sand propagates downwardly in figure 3 along a longitudinal axis of the cleaning apparatus 18a, and a transverse bore 18a2 in which the fluid or sand will propagate from the central bore 18a1 in a transverse direction with respect to the longitudinal axis of the cleaning apparatus, as shown in figure 3. The cleaning apparatus 18a of figure 3 can be the "Jet Blaster" tool that is owned and operated by Schlumberger Technology Corporation of Houston, Texas. In operation, the Jet Blaster cleaning apparatus 18a of figure 3 will propagate a fluid or sand at a high velocity through the central bore 18a1 and through the transverse bore 18a2, the fluid or sand being blasted against the inside 16a of the pipe or tubing or casing 16 at the high velocity thereby removing the corroded areas 24 from the inside 16a of the pipe or tubing or casing 16. The corrosive elements of the corroded areas 24 will fall into the container 18b when the corrosive elements are removed from the inside 16a of the pipe or tubing or casing 16 by the Jet Blaster cleaning apparatus 18a of figure 3.

Referring to figures 4, 5A and 5B, an alternate embodiment of the corrosion monitoring tool 14 of figure 1 is illustrated. In figure 4, the alternate embodiment of the corrosion monitoring tool 14 of figure 1 is an Ultrasonic Imaging Tool that uses a single rotating transducer 26, housed in a sub at the bottom of the tool, to give full coverage of the tubing or casing 16. In figure 4, the transducer 26 is used to resonate the tubing or casing 16. The fundamental mode of resonance is analyzed in the received waveform to obtain information regarding the existence of corrosion on the inside 16a of the pipe or tubing or casing 16. The Ultra Sonic Imaging Tool of figure 4 is owned and operated by Schlumberger Technology Corporation of Houston, Texas. The principle of operation of

the Ultrasonic Imaging Tool of figure 4 is discussed below with reference to figures 5A and 5B. In figure 5A, a sonic monopole transmitter 28 produces positive compressional waves in the tubing or casing 16 on both sides of the transmitter via volumetric expansion and constraction of the transmitter 28. Compressional waves are generated in the pipe or tubing or casing 16, the compressional waves propagating longitudinally along the axis of the pipe or tubing or casing 16. One or more corroded areas 24 on the inside of the pipe or tubing or casing 16 will affect the propagation of the compressional waves which are propagating along the pipe or tubing or casing 16. A receiver 30 will record the compressional waves which are received from the pipe or tubing or casing 16, that record produced by the receiver 30 reflecting the extent of the corroded areas 24 which exist on the inside of the pipe or tubing or casing 16. In figure 5B, a sonic dipole transmitter 32 produces a positive shear wave on one side of the pipe or tubing or casing 16 and a negative shear wave on the other side of the pipe or tubing or casing 16. No net volume change is produced. A positive shear wave propagates longitudinally on one side of the pipe or tubing or casing 16 and a negative shear wave propagates longitudinally on the other side of the pipe or tubing or casing 16. One or more corroded areas 24 on the inside of the pipe or tubing or casing 16 will affect the propagation of the shear waves which are propagating along the pipe or tubing or casing 16. A receiver 34 will record the shear waves which are received from the pipe or tubing or casing 16, that record produced by the receiver 34 reflecting the extent of the corroded areas 24 which exist on the inside of the pipe or tubing or casing 16. The principle of operation described above with reference to figures 5A and 5B is also discussed in U.S. Patent 5,036,945 to Hoyle et al, the disclosure of which is incorporated by reference into this specification.

A functional description of the operation of the downhole pipe or casing repair apparatus 10 of the present invention will be set forth in the following paragraphs with reference to figures 1 through 5B of the drawings.

Assume that the downhole pipe or casing repair apparatus 10 of figures 1 and 2, which includes the corrosion monitoring tool 14, the packer sealing apparatus 22, the surface

treatment apparatus 18, the packer sealing apparatus 23, and the plating apparatus 20, is lowered downwardly into the pipe or tubing or casing 16, as indicated by downwardly directed arrow 17 in figure 2. In figure 2, in response to the downward movement of the downhole pipe or casing repair apparatus 10, the fingers 14a of the corrosion monitoring tool 14 will flex whenever corroded areas 24 are encountered on the inside 16a of the tubing 16 thereby generating an electrical signal which propagates uphole along the central conductor 21 and records the existence of corroded areas 24 on the inside 16a of the pipe or tubing or casing 16. The packer sealing apparatus 22 will seal off the corrosion monitoring tool 14 of figure 1 from the surface treatment apparatus 18 and the packer sealing apparatus 23 will seal off the surface treatment apparatus 18 from the plating apparatus 20, since an electrolyte solution 20c will be disposed above the packer sealing apparatus 23 inside the pipe or tubing or casing 16 of figure 2. In figure 2, in response to the downward movement of the downhole pipe or casing repair apparatus 10, when the corrosion monitoring tool 14 is recording the existence of the corroded areas 24 on the inside of the pipe or tubing or casing 16, and when the packer sealing apparatus 22 and 23 are both firmly sealed against the inside 16a of the tubing or casing 16, the cleaning apparatus 18a of the surface treatment apparatus 18 is busy cleaning the inside 16a of the pipe or tubing or casing 16 by removing the corroded areas 24 from the inside 16a of the pipe or tubing or casing 16. When the corroded areas 24 are removed from the inside 16a of the tubing or casing 16 by the cleaning apparatus 18a, the removed corroded areas 24 are deposited into the container 18b of the surface treatment apparatus 18. In figure 3, the cleaning apparatus 18a cleans the inside 16a of the pipe or tubing or casing 16 by initially rapidly propagating a fluid or sand down the central bore 18a1 of the cleaning apparatus 18a, in figure 3, at a high velocity and then rapidly propagating the fluid or sand transversely through the transverse bore 18a2 of the cleaning apparatus 18a at a high velocity, the rapidly propagating fluid or sand which is transversely propagating in the transverse bore 18a2 striking the inside 16a of the pipe or tubing or casing 16 while the downhole pipe or casing repair apparatus 10 is still moving downwardly inside the pipe or tubing or casing 16. As a result, the rapidly propagating fluid or sand, exiting the transverse bore 18a2 of figure 3, will function as a jet blaster since the fluid or sand will

blast against the inside 16a of the pipe or tubing or casing 16 while the downhole pipe or casing repair apparatus 10 is moving downwardly inside the pipe or tubing or casing 16 of figures 1 or 2. The corroded areas 24 are removed from the inside 16a of the pipe or tubing or casing 16, the removed corroded areas 24 being deposited into the container 18b of the surface treatment apparatus 18. In addition to or simultaneously with the blasting of the fluid or sand from the transverse bore 18a2 of the cleaning apparatus 18a of figure 3 against the inside of the tubing or casing 16, the inside 16a of the tubing or casing 16 can be acid washed using an acid solution comprised of approximately 15% of HCL in order to remove any rust from the inside 16a of the tubing or casing 16 prior to a plating operation using the plating apparatus 20 of figures 1 and 2. In figure 2, in response to the downward movement of the downhole pipe or casing repair apparatus 10, when the corrosion monitoring tool 14 is recording the existence of the corroded areas 24 on the inside of the tubing or casing 16, and when the packer sealing apparatus 22 and 23 are both firmly sealed against the inside 16a of the tubing or casing 16, and when the cleaning apparatus 18a of the surface treatment apparatus 18 is cleaning the inside 16a of the pipe or tubing or casing 16, the plating apparatus 20 is busy plating a new metallic surface on the inside 16a of the tubing or casing 16. In figure 2, a voltage V is applied across the anode 20a and the cathode 20b when an electrolyte solution 20c is disposed inside the pipe or tubing or casing 16 above the packer sealing apparatus 23. As a result, due to an electrolytic reaction which is taking place between the anode 20a and the cathode 20b in figure 2, a new metallic layer is being deposited on the inside 16a of the tubing or casing 16 of figure 2, the new metallic layer being deposited over the cleaned areas on the inside 16a of the tubing or casing 16 where the corroded areas 24 previously existed. The new metallic layer can be either Chromium, Iron, Nickel, or Copper.

In figure 2, the downhole pipe or casing repair apparatus 10 of figure 2 is now moved upwardly inside the pipe or tubing or casing 16 for the purpose of confirming the repaired pipe or tubing or casing, as indicated by the upwardly directed arrow 19 in figure 2. During the movement upwardly inside the pipe or tubing or casing 16, the corrosion monitoring tool 14 of figures 1 and 2 will now create a new record of the existence of any

remaining corroded areas 24, if any, on the inside 16a of the tubing or casing 16. The fingers 14a of the corrosion monitoring tool 14 of figure 2 will flex when a corroded area 24 is encountered on the inside 16a of the pipe or tubing or casing 16. However, in view of the above referenced cleaning operation, wherein the inside 16a of the pipe or tubing or casing 16 was cleaned by the surface treatment apparatus 18 and the inside 16a was plated by the plating apparatus 20, the new record of the inside 16a of the pipe or tubing or casing 16 that was created by the corrosion monitoring tool 14 will now record the absence of any corroded areas 24 on the inside 16a of the pipe or tubing or casing 16.

Instead of using the electrolytic plating apparatus 20 shown in figure 2, a chemical plating method and apparatus could be used. Electroless or chemical plating is a chemical deposition process autocatalytically occurring on the metal surface without applying electric current in contrast to the conventional electroplating. The deposited metal ions are reduced on the metal surface by reducing agents instead of current. The reducing agents give up electrons to the deposited ions directly forming a metal layer which is coated on the substrate surface. Due to the chemical reaction, the thickness of the coated metal layer is very uniform and accurate as compared with electroplating, especially in connection with a complicated shape of metal parts. Electroless Ni and its alloy (Ni-P) were proven superior in corrosion resistance, especially in a highly corrosive oil and gas production environment, which may contain H2S, CO2 and brine at high pressure and high temperature.

In addition, instead of using the corrosion monitoring tool 14 shown in figure 2, the corrosion monitoring tool shown in figures 4 and 5 could be used in order to accomplish the function of the downhole pipe or casing repair apparatus 10 of the present invention.

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.